Survey Trawl Workshop
Working Paper

Analysis of Catch-at-Length Data from the NMFS Industry Survey Trawl Study Conducted by the R/V *Albatross IV* and F/V *Sea Breeze* 28 October – 6 November 2002

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Introduction

A cooperative NMFS/Industry survey trawl study was conducted on the R/V Albatross IV and the F/V Sea Breeze during October 6 through November 2002. Two different trawl gear configurations were tested on the Albatross IV – a "correctly" rigged net and a net that was intentionally rigged with mismatched warp lengths and other errors. The experiment was conducted to determine the differences in catch (if any) between the two gear configurations. Some gear experts speculated that the two gear configurations would have different selectivity characteristics. In order to examine this possibility, R/V Albatross catches at length were evaluated using a Kolmogorov-Smirnov test (K-S) to determine if statistically significant differences are evident.

Application of the K-S test assumes that both trawl gears encountered the same size distribution of fish. It can be used in testing gear selectivity in paired tow experiments where this assumption is reasonable. In the design of this experiment, the different R/V Albatross trawl configurations were towed at different times – usually a day apart. It is possible that the K-S test results may reflect not only the performance of the gear but changing size distributions of fish in the area. Without knowing how (or if) the size distribution of fish encountered by the different gears changed, it is not possible to predict the bias that this may introduce into the analysis. While a statistical technique was not identified to correct for this possibility, the F/V Sea Breeze conducted paired tows with most R/V Albatross tows in this experiment. If one assumes the F/V Sea Breeze gear is likely to fish the same way on each day (that is, retain similar catch/length compositions of a species), changes in the length composition of the F/V Sea Breeze tows might reflect changes in the size distribution of the fish encountered. Performing the K-S test on the F/V Sea Breeze catches may indicate if the length distribution of a species encountered by the survey vessels changed from one day to the next.

Data/Methods

R/V Albatross IV Catch at Length Analysis

Catch at length was examined for Albatross tows using an optimal gear (Gear 0, or G0) and gear that was intentionally configured incorrectly (Gear 1, or G1). Data were obtained from the file AL-0211len 2.xls provided by the NEFSC. Available catch at length data by species and area is summarized in Table 1. The data was summed by area for tows conducted in each of three areas sampled in order to account for the possibility that different size distributions were present in each area. In the case of species with very small numbers of fish caught in an area or areas (monkfish, white hake) the data was also pooled across all areas.

The analytical method used to analyze the data is described by DeAlteris et al (1999). The numbers of fish caught at each length were converted to a cumulative percentage of fish caught at each length. Cumulative frequency plots for each species are shown in Figure 1 through Figure 18. The plots provide a visual comparison of the catches for each gear configuration and show that the catch at length is similar to a logistic cumulative distribution function. The K-S test compares the cumulative frequencies from each gear configuration by testing the absolute value of the maximum difference.

$$D = \left| F_0 / n_0 - F_1 / n_1 \right|$$

where:

F = cumulative number of fish caught up to and including each length for a particular gear (0 or 1)

n = total number of fish caught by each gear (0 or 1)

The significance of this difference was examined using a two-tailed K-S test statistic at an alpha level of 0.01 and 0.05. The critical value of the test statistic is:

$$D = K\alpha \sqrt{n_0 + n_1 / n_0 n_1}$$

where $K\alpha = \sqrt{0.5\left[-\ln(\alpha/2)\right]}$.

The hypotheses tested are:

H_o: No difference in the length-frequency distributions of the catches in the two gear configurations

H_a: There is a difference in the length-frequency distributions of the catches in the two gear configurations.

F/V Sea Breeze Catch at Length Analysis

F/V Sea Breeze catch/length data was obtained from the file Sblengths.xls provided by the NEFSC. The data was summed by area for trawls conducted in each of three areas sampled in order to account for the possibility that different size distributions were present in each area. In the experiment, F/V Sea Breeze tows were paired with R/V Albatross IV tows. The F/V Sea Breeze catch resulting from tows paired with one R/V Albatross gear configuration in a given area were compared to the F/V Sea Breeze tows paired with the other R/V Albatross gear configuration in the same area. For the tows in Area 1, this resulted in comparing the F/V Sea Breeze tows on two successive days. In Areas 2 and 3, some of the F/V Sea Breeze tows occurred on the same day. Species length measurements are not available for all F/V Sea Breeze tows. As a result, in all but five cases the comparisons are between the catches resulting from as few as one F/V Sea Breeze tow paired with a particular R/V Albatross gear configuration. Available catch at length data by species and area is summarized in Table 3. In this table, comparisons that include only one tow paired with a particular Albatross gear configuration are italicized. (Data from F/V Sea Breeze tow number 18, which used a different ground cable than other tows in Area 2, was not used).

The hypotheses tested are:

> H_o: No difference in the length-frequency distributions of the catches between the F/V Sea Breeze tows paired with R/V Albatross Gear 0 in an area and the F/V Sea Breeze tows paired with R.V Albatross Gear 1 in the same area.
> H_a: There is a difference in the length-frequency distributions of the catches between the F/V Sea Breeze tows paired with R/V Albatross Gear 0 in an area and the F/V Sea Breeze tows paired with R.V Albatross Gear 1 in the same area.

Results

The comparisons of catch at length for the two R/V Albatross gear configurations identified statistically significant differences in eight of the twenty-five species/area combinations for which data was available. In seven of the eight combinations, the results were significant at an alpha of 0.01. Five of the eight statistically significant results occurred in Area 3, the area with the shallowest average depth. Length frequency information is available for more than one area for only five species. Of these five species, two have significant differences in one area but not in any other area. For the two instances where data was pooled across areas due to small numbers of fish, no statistically significant differences were observed. Results are summarized in Table 2. The differences in cod catches, while the third largest value observed, are not statistically significant because of the low numbers of fish caught.

The cumulative frequency plots show that for some species/area combinations, the R/V Albatross gear configurations performed nearly identically (e.g. haddock, witch flounder, white hake). There are some plots that appear to show a difference, but it was determined not to be significant using the K-S test (e.g. cod, winter flounder). The silver hake and red hake plots are interesting in that the two configurations performed differently in one area but not in others. In Area 1, both configurations caught more small silver hake, but Gear 0 caught a higher percentage of small fish. A similar pattern was seen with red hake catches in Area 3: both gears caught more small fish than in other areas, but Gear 0 caught a higher percentage of small fish. It is possible that not only did these gears encounter a different size distribution of fish in these areas, but that Gear 0 retained more small fish.

The comparisons of catch at length for the F/V Sea Breeze tows paired with R/V Albatross gear configurations identified statistically significant differences in fourteen of the twenty species/area combinations examined. Eleven were significant at an alpha of 0.01 and three were significant at an alpha of 0.05. The fact that there are only small numbers of tows with length data for some species may influence these results (see **Discussion**, below).

Of the eighteen species/area combinations common to the F/V Sea Breeze and the R/V Albatross analyses, eight combinations had the same results in each analysis and ten resulted in differences between the two. There are four species/area combinations with statistically significant differences common to both: silver hake/Area 1, herring/Area 2, little skate/Area 3, and butterfish/Area 3. There are four species/area combinations where neither analysis found significant differences: witch flounder/Area 2, winter flounder/Area 2, and goosefish/Areas 2 and 3. There are eight species/area combinations where the F/V Sea Breeze had significant differences but the R/V Albatross configurations did not: cod/Area 1, white hake/Area 2, red hake/Area 2, silver hake/Area 2, redfish/Area 2, plaice/Area 2, spiny dogfish/Area 2, and barndoor skate/Area 3. There are two species/area combinations where the R/V Albatross gear configurations had significant differences but the F/V Sea Breeze did not: redfish/Area 1 and fourspot flounder/Area 3.

Discussion

For the R/V Albatross tows, nearly a third (eight of twenty-five) species/area combinations examined showed different length/frequency distributions between the gear configurations tested. It is not possible to definitively identify the cause of the differences. For example, three of the eight species/area combinations with significant differences were for schooling fish (silver hake, butterfish, and herring). The behavior of these fish could easily result in changing size distributions in an area if the two gears are not tested at the same time – or the different bottom trawl gear configurations may affect the catch of schooling, pelagic fish differently than more sedentary species. Further investigation is warranted since differences were noted in a relatively large number of species/area combinations.

Comparing the R/V Albatross results with the F/V Sea Breeze is not enlightening. As noted in the previous section, there were ten (out of eighteen) combinations where results from the F/V Sea Breeze and R/V Albatross analyses differed. This result should be viewed with caution. The critical value of the test statistic is defined primarily by the number of fish sampled by each gear, without reference to the number of tows producing those fish. When large numbers are caught (e.g. silver hake, redfish, herring) the test is very sensitive. In interpreting the results, however, the number of tows should be considered. Statistically significant results between only two tows may reflect tow-to-tow variation rather than a real difference in performance between the gears tested. This is a particular problem for analyzing the F/V Sea Breeze catch at length data, since there are few tows with length data for some species. The lack of length data from the F/V Sea Breeze tows make it doubtful that the performance of this gear can be used to indicate whether the R/V Albatross tows encountered changes in the size distribution of fish.

With the R/V Albatross tows, length measurements were taken on all tows for the species examined, and there is not a single instance where the comparison is based on only one tow that caught a species in a particular gear configuration. There are, however, some R/V Albatross tows where the number of fish caught on each tow was very low – particularly for plaice, goosefish, and cod.

Comparisons between the R/V Albatross and F/V Seabreeze length/frequency distributions are not summarized here. Preliminary investigation showed that there was often a difference in the length/frequency distributions between either of the R/V Albatross gear configurations and the F/V Sea Breeze tows. This is not surprising, since the vessels used different gear and towed at different speeds.

Literature cited:

DeAlteris, Joseph, Laura Skrobe, and Kathleen Castro. 1999. Experimental designs and data analysis methodologies for the evaluation of trawl performance based on catch comparisons. Presented at the Small Mesh Experimental Workshop, University of Rhode Island, August, 1999.

Species	Area 1	Area 2	Area 3	All Areas Pooled
Cod	**X**			
Haddock	**X**			
Winter Flounder			**X**	
Witch Flounder		**X**		
White Hake	**X**	**X**	**X**	**X**
Red Hake	**X**	**X**	**X**	
Silver Hake	**X**	**X**		
Fourspot flounder			**X**	
Redfish	**X**	**X**		
Goosefish	**X**	**X**	**X**	**X**
American Plaice		**X**		
Winter Skate			**X**	
Little Skate			**X**	
Barndoor Skate			**X**	
Herring		**X**		
Spiny Dogfish		**X**		
Butterfish			**X**	

Table 1 – Species/area combinations analyzed for differences in catch at length between two Albatross gear configurations

Species	Area 1	Area 2	Area 3	All Areas Pooled
Cod	0.23208			
Haddock	0.02258			
Winter Flounder			0.1315	
Witch Flounder		0.1468		
White Hake	0.1765	0.0696	0.5	
Red Hake	0.0874	0.04451	0.2098**	0.0102
Silver Hake	0.2786**	0.02261		
Fourspot flounder			0.13320*	
Redfish	0.0661**	0.1079		
Goosefish	0.25	0.1686	0.1979	0.0788
American Plaice		0.0921		
Winter Skate			0.5671**	
Little Skate			0.1508**	
Barndoor Skate			0.1951	
Herring		0.1513**		
Spiny Dogfish		0.1069		
Butterfish			0.2277**	

Table 2 – Calculated values of D and results of K-S test for significance for R/V Albatross gear configuration tests. (* $p < 0.05$, ** $p < 0.010$)

Species	Area 1	Area 2	Area 3
Cod	**X**		
Haddock			
Winter Flounder			**X**
Witch Flounder	***X***	***X***	**X**
White Hake		***X***	
Red Hake		***X***	
Silver Hake	***X***	***X***	
Fourspot flounder			***X***
Redfish	***X***	***X***	
Goosefish		**X**	**X**
American Plaice		***X***	
Winter Skate			
Little Skate			***X***
Barndoor Skate			***X***
Herring		***X***	
Spiny Dogfish		***X***	
Butterfish			***X***

Table 3 – Species/area combinations analyzed for differences in catch at length from F/V Sea Breeze tows paired with R/V Albatross tows. Combinations where there is only one F/V Sea Breeze tow paired with a R/V Albatross gear configuration are in italics.

Species	Area 1	Area 2	Area 3
Cod	0.2557**		
Haddock			
Winter Flounder			0.2193
Witch Flounder	0.3973*	0.1066	0.3781**
White Hake		0.3141**	
Red Hake		0.1616**	
Silver Hake	0.2258**	0.1847**	
Fourspot flounder			0.1558
Redfish	0.1179	0.3203**	
Goosefish		0.2753	0.8067
American Plaice		0.2369**	
Winter Skate			
Little Skate			0.2387**
Barndoor Skate			0.3743**
Herring		0.2415**	
Spiny Dogfish		0.7418**	
Butterfish			0.7503**

Table 4 – Calculated values of D and results of K-S test for significance for comparisons shown in Table 3. (* $p < 0.05$, ** $p < 0.010$)

Explanation of Figures

Each figure plots the cumulative frequency (percent) caught for a given species. A data point is plotted at each length class.

Area and gear configurations legends are of the form A<area number>G<gear configuration>, for example:

A1G0: Area 1, Albatross gear configuration 0
A2G1: Area 2, Albatross gear configuration 1

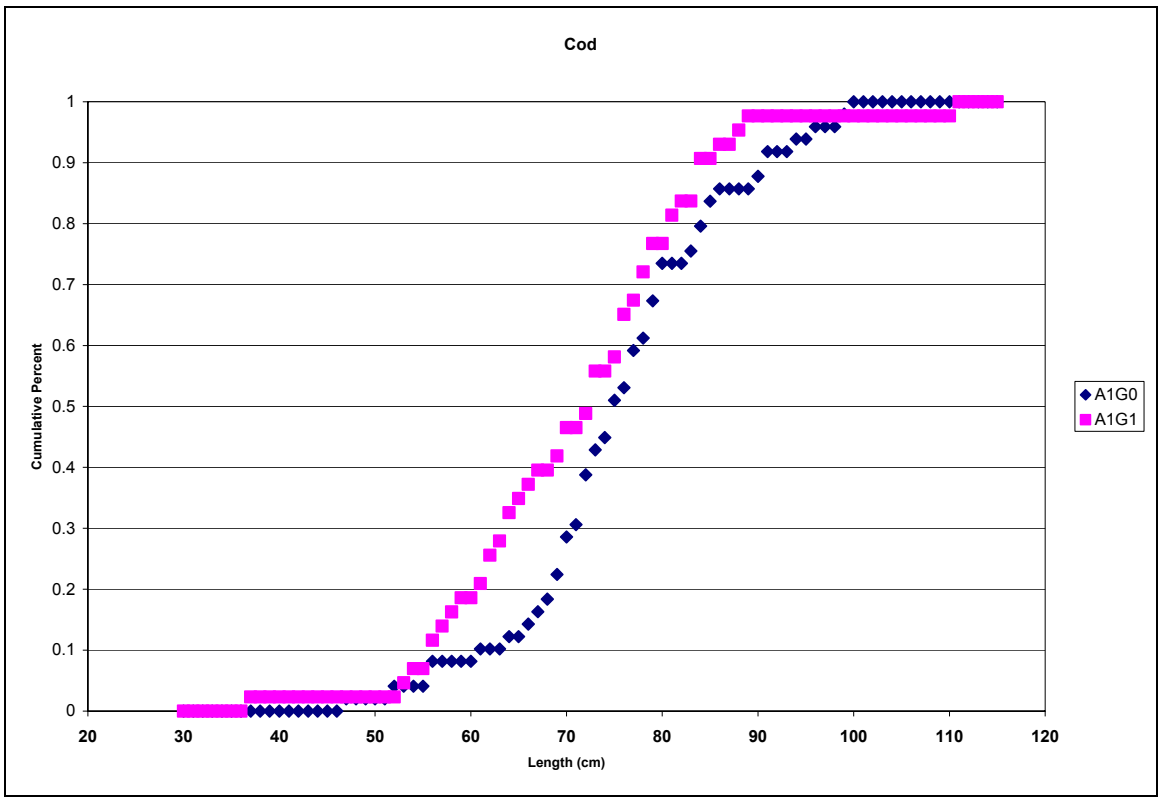

Figure 1 – R/V Albatross IV cumulative catch at length – cod.

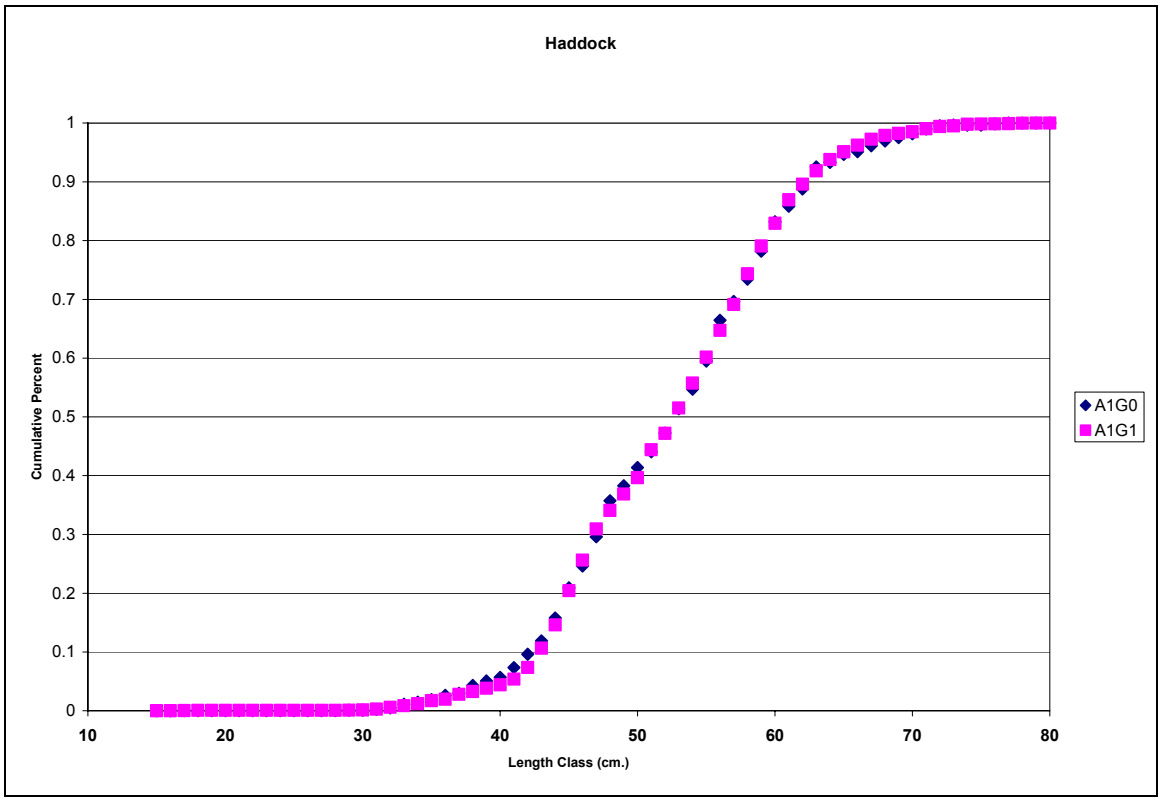

Figure 2 – R/V Albatross IV cumulative catch at length – haddock.

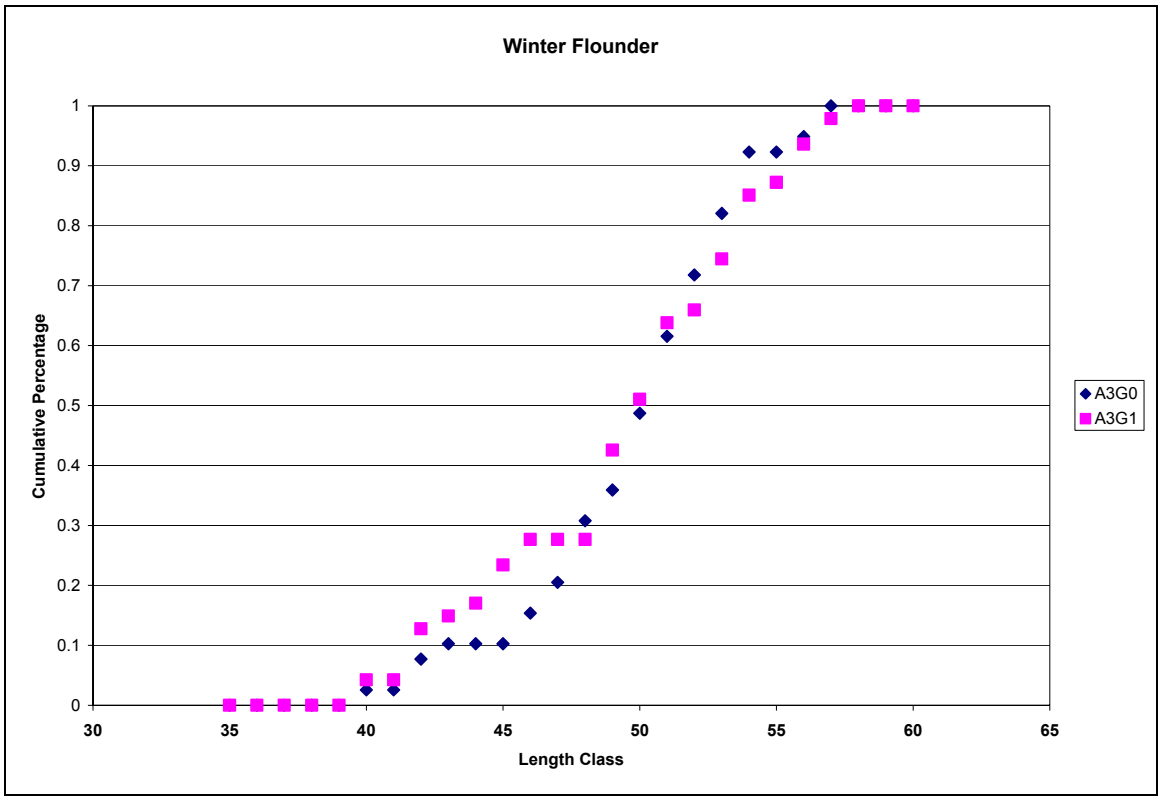

Figure 3 – R/V Albatross IV cumulative catch at length – winter flounder.

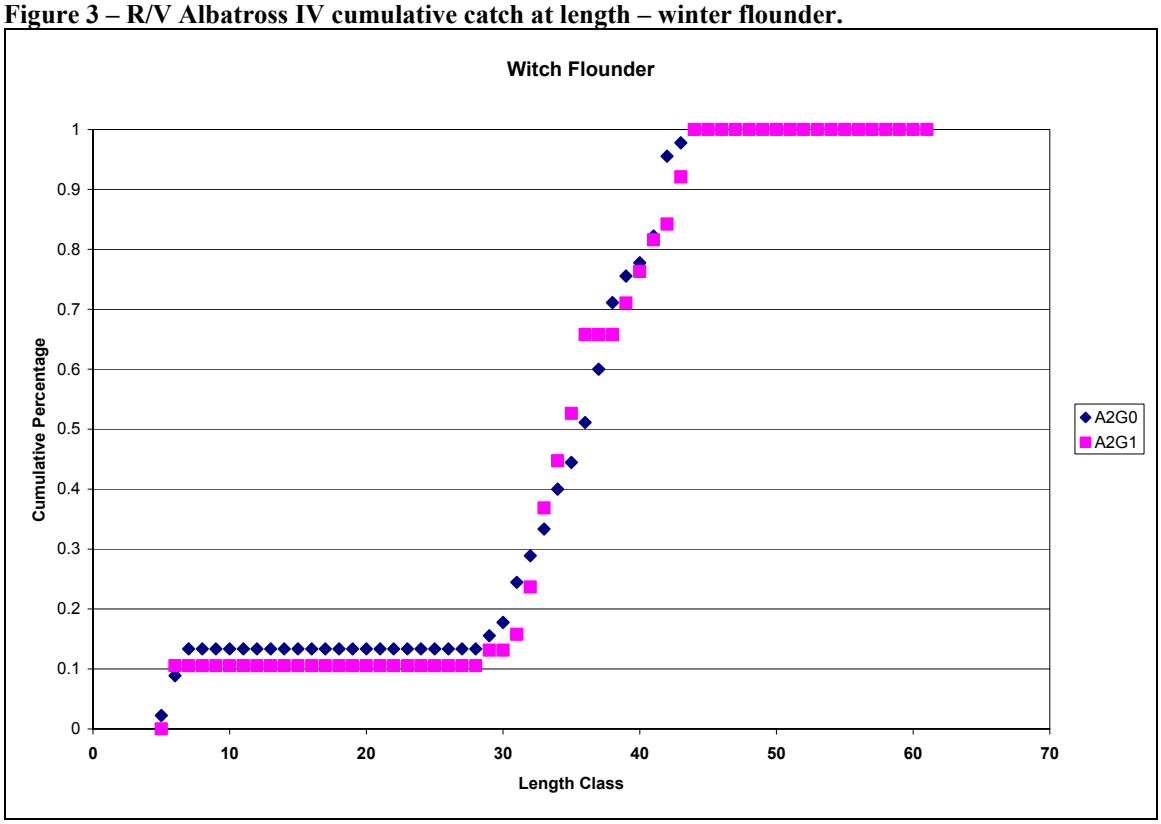

Figure 4 – R/V Albatross IV cumulative catch at length – witch flounder

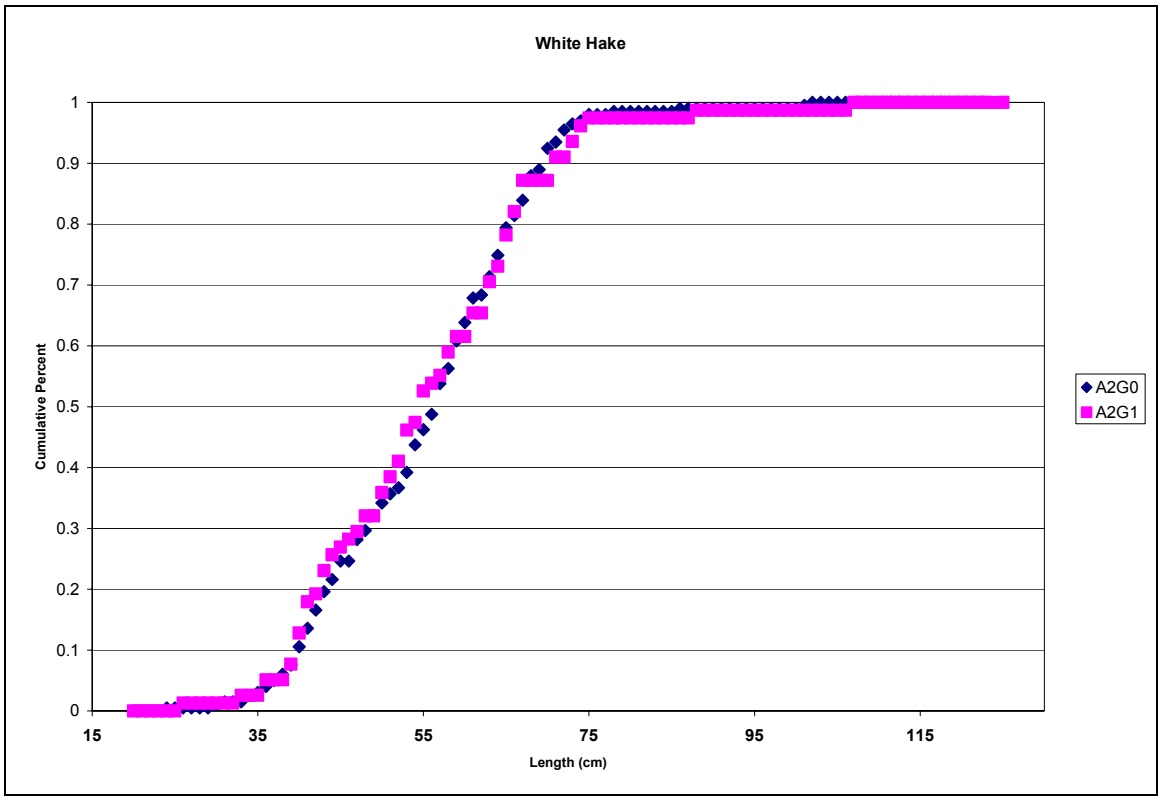

Figure 5 – R/V Albatross IV cumulative catch at length – white hake, Area 2.

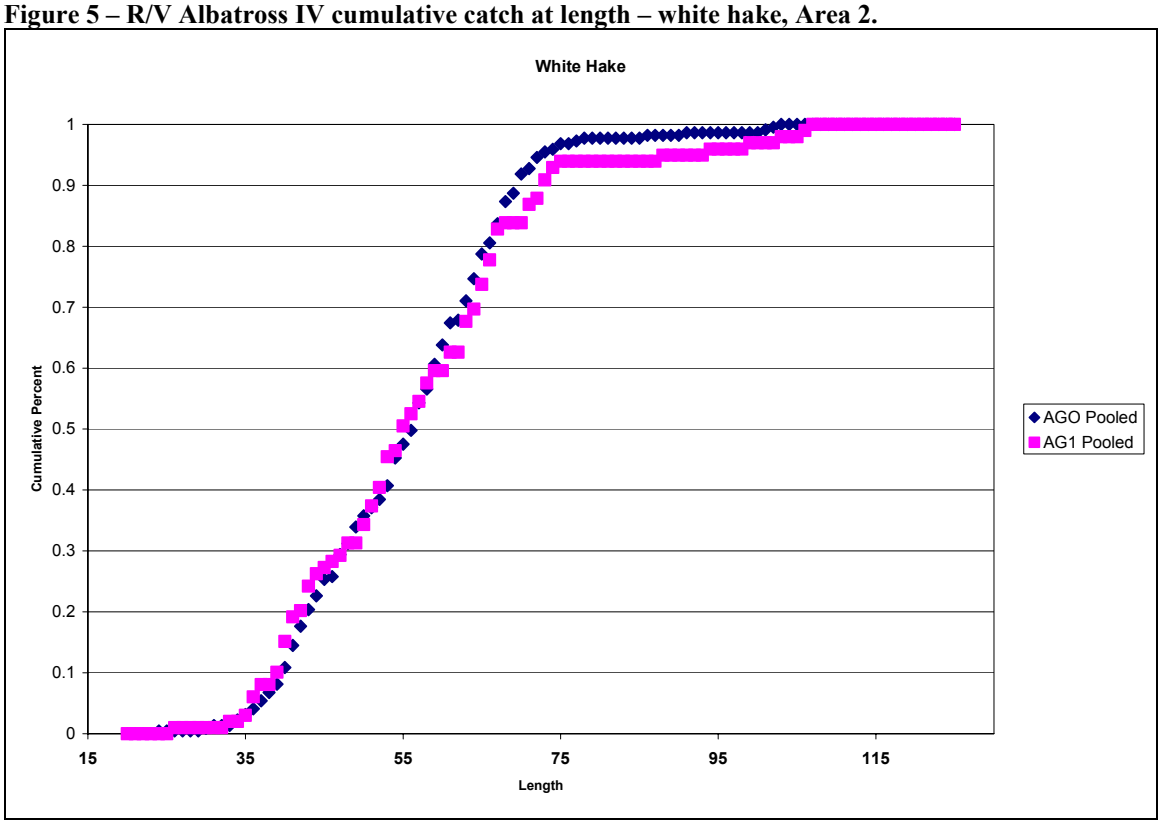

Figure 6 – R/V Albatross IV cumulative catch at length – pooled.

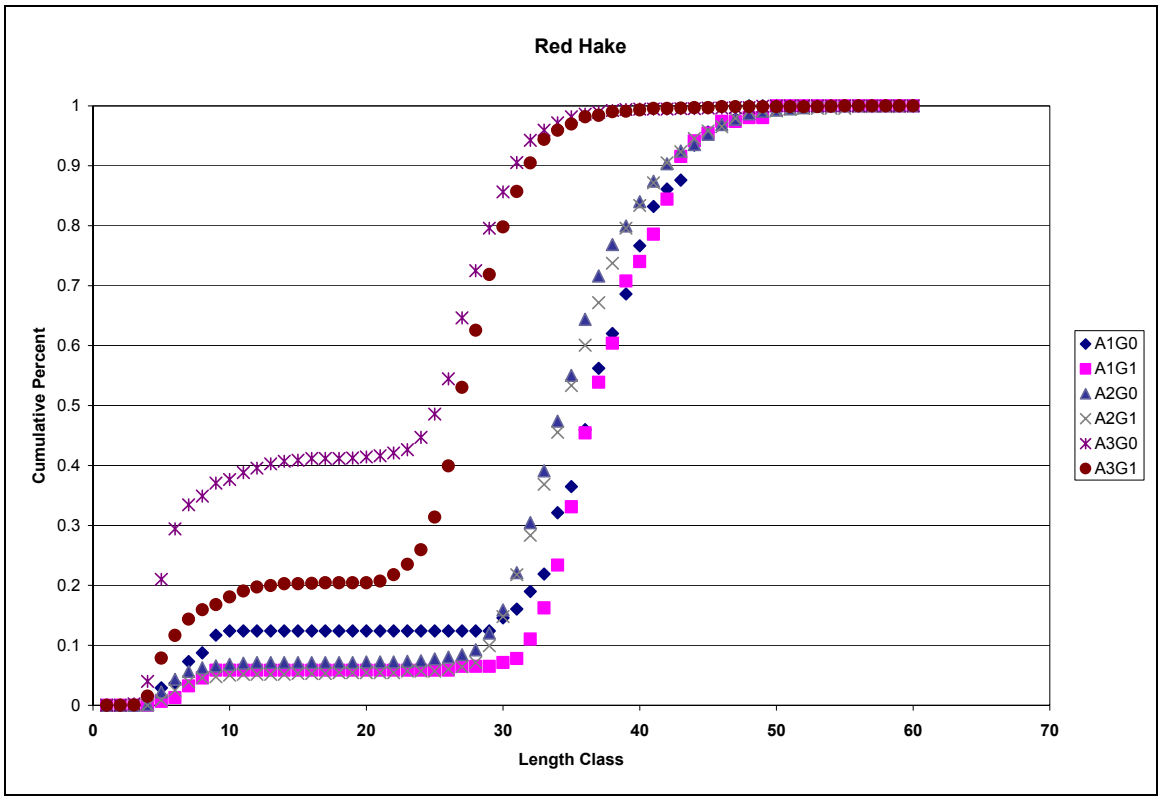

Figure 7 – R/V Albatross IV cumulative catch at length – red hake.

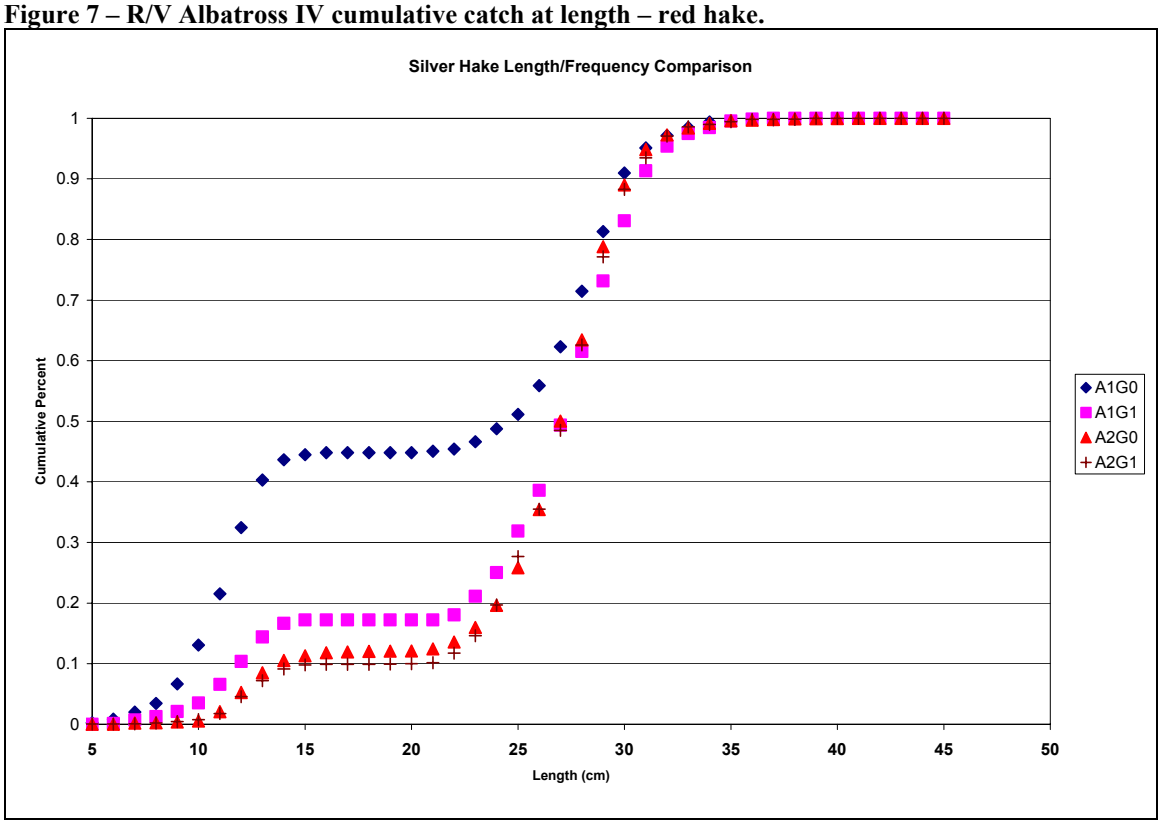

Figure 8 – R/V Albatross IV cumulative catch at length – silver hake.

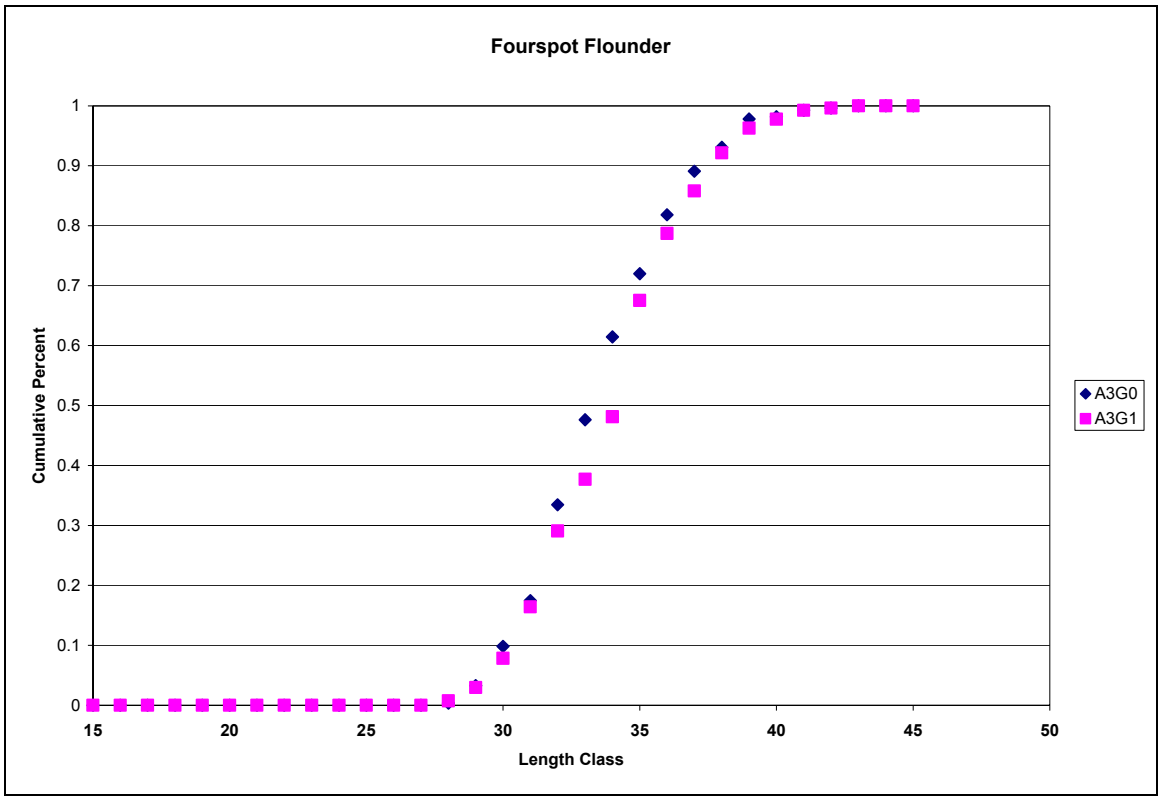

Figure 9 – R/V Albatross IV cumulative catch at length – fourspot flounder

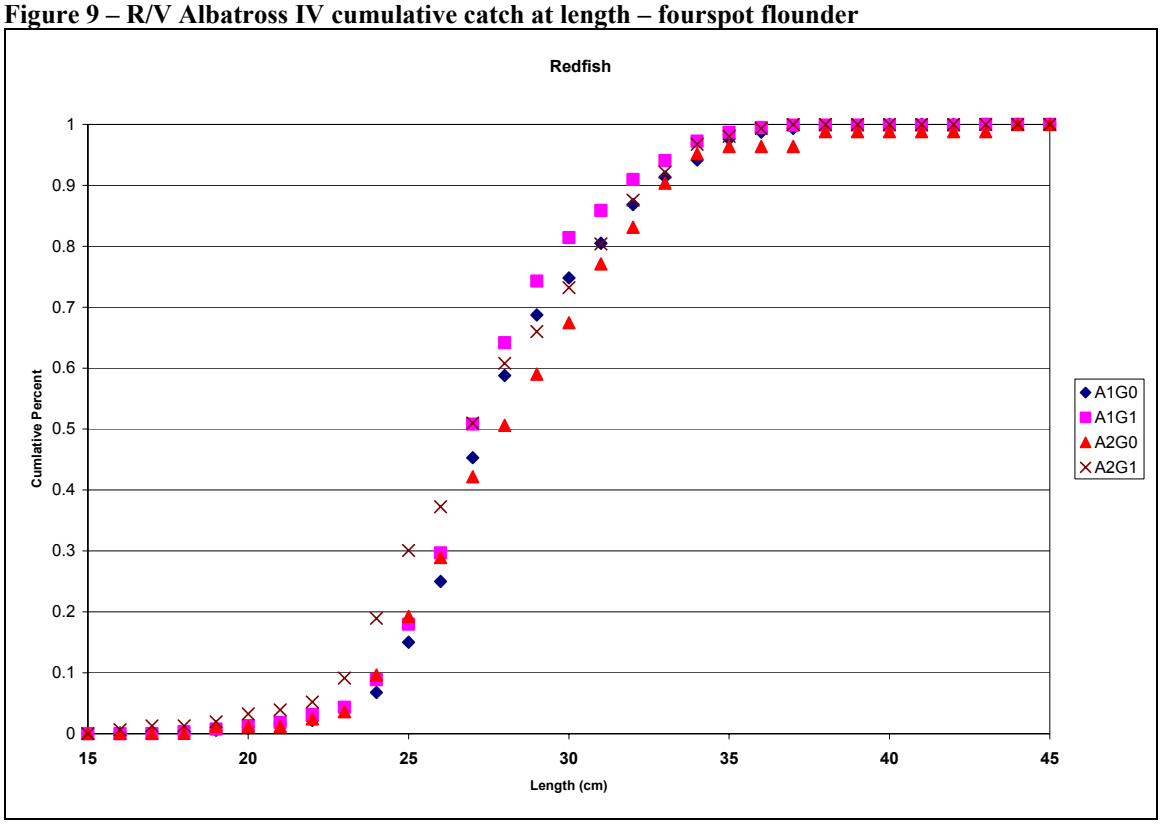

Figure 10 – R/V Albatross IV cumulative catch at length – redfish.

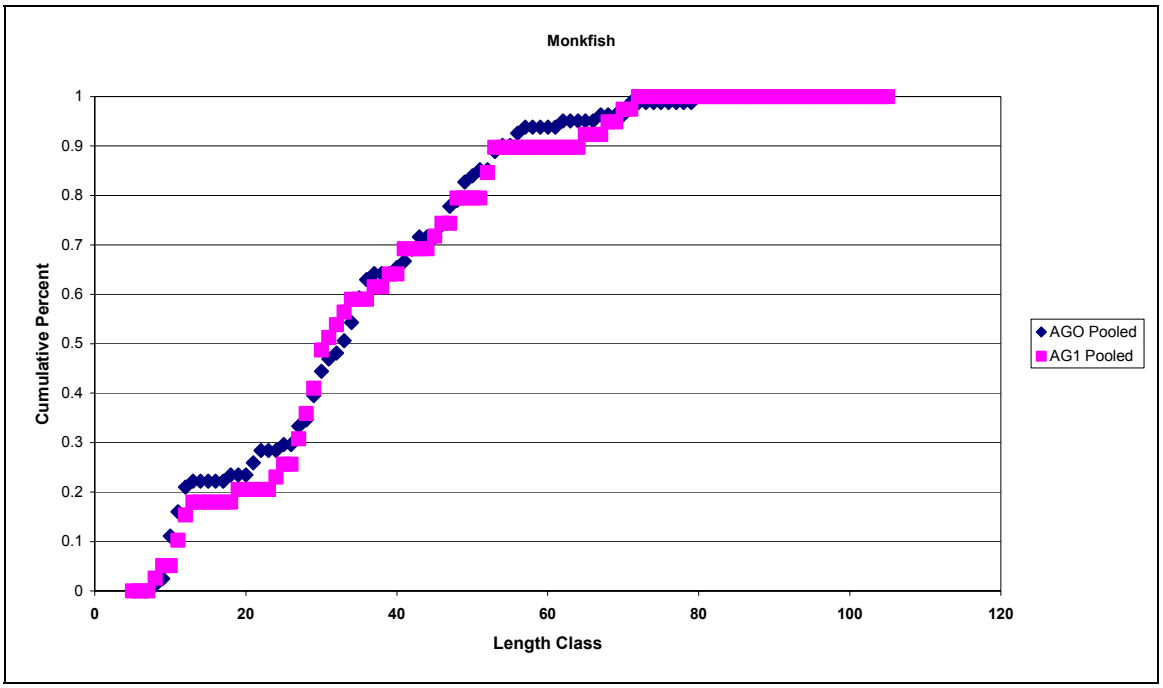

Figure 11 – R/V Albatross IV cumulative catch at length – monkfish.

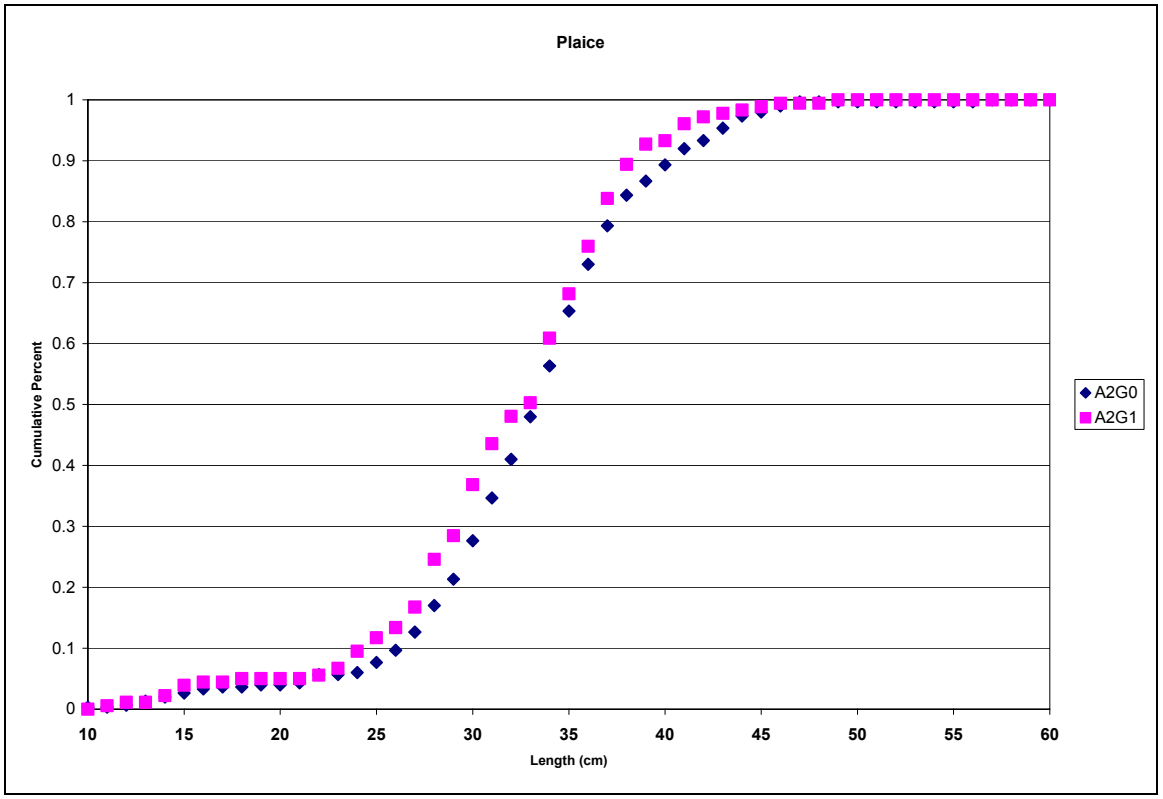

Figure 12 – R/V Albatross IV cumulative catch at length – plaice.

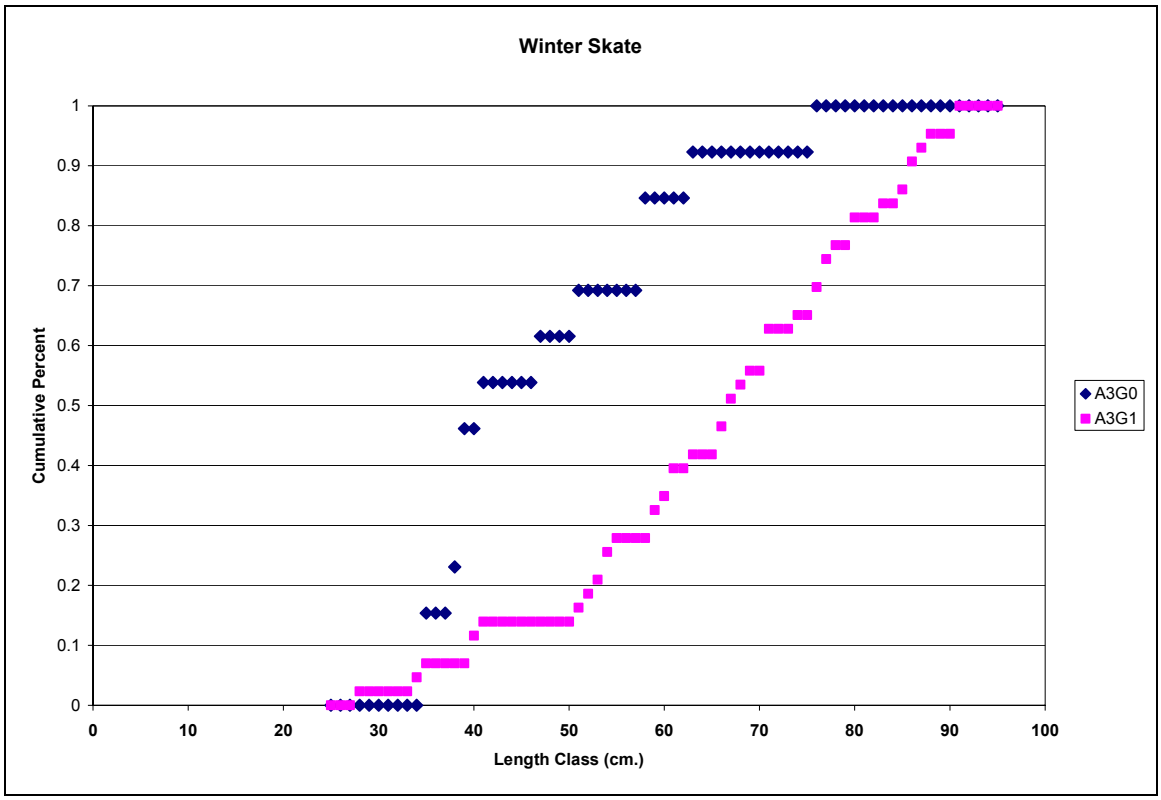

Figure 13 – R/V Albatross IV cumulative catch at length – winter skate.

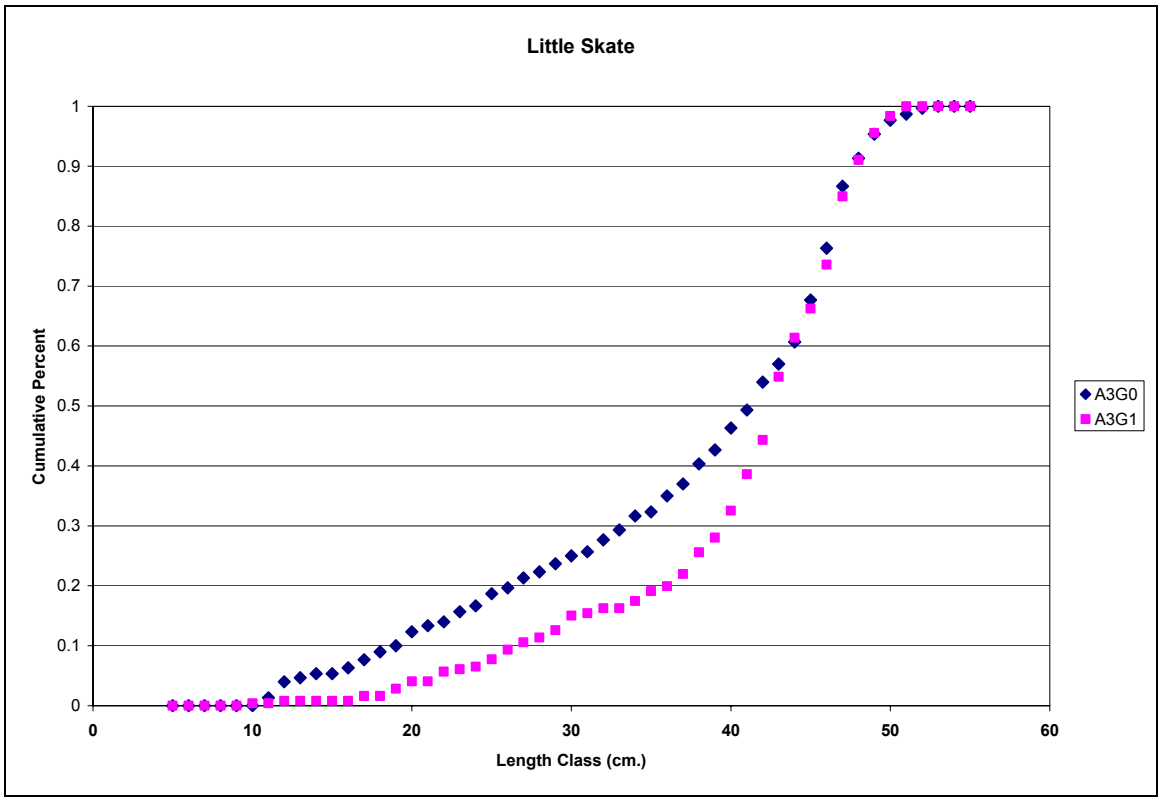

Figure 14 – R/V Albatross IV cumulative catch at length – little skate.

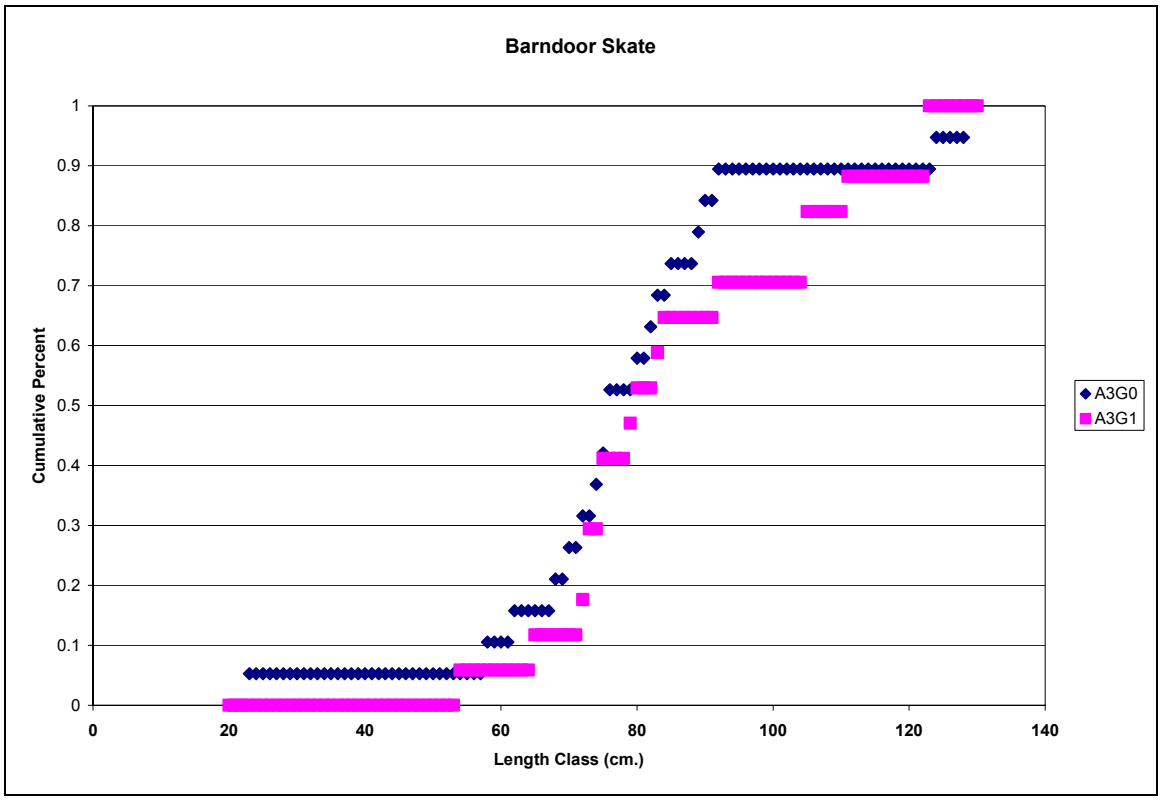

Figure 15 – R/V Albatross IV cumulative catch at length – barndoor skate.

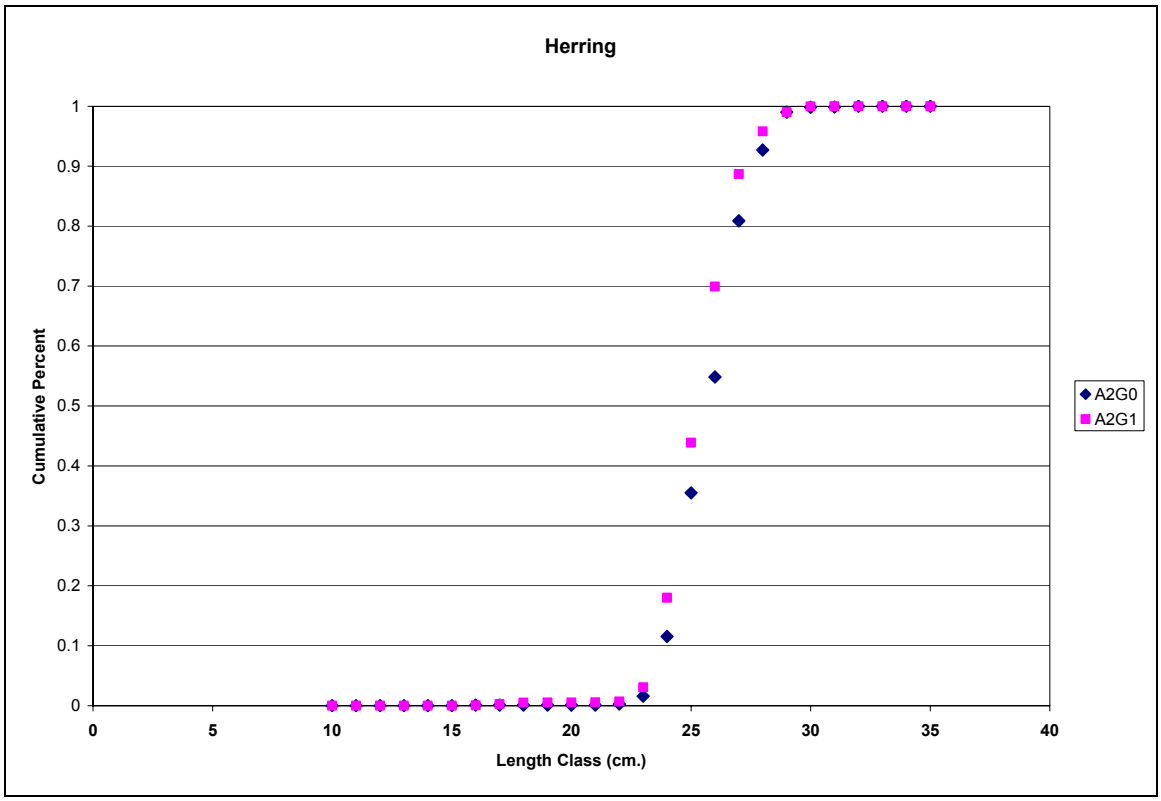

Figure 16 – R/V Albatross IV cumulative catch at length – herring.

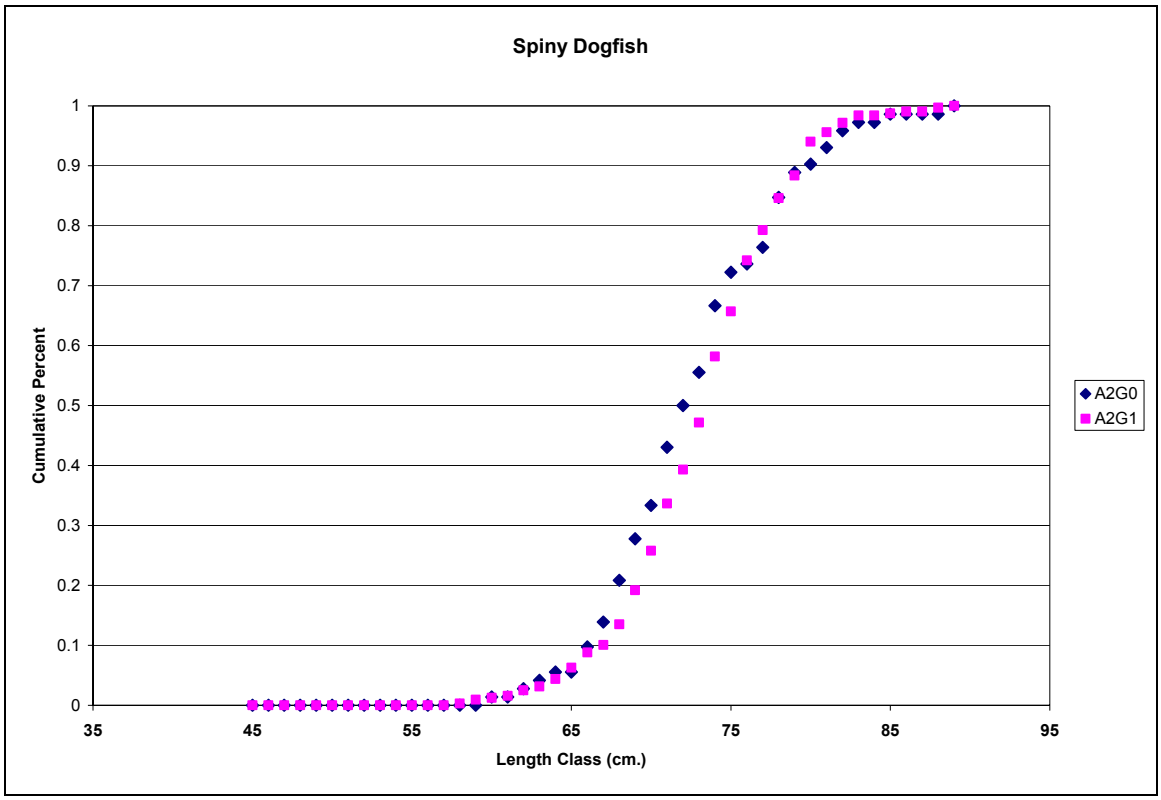

Figure 17 – R/V Albatross IV cumulative catch at length – spiny dogfish.

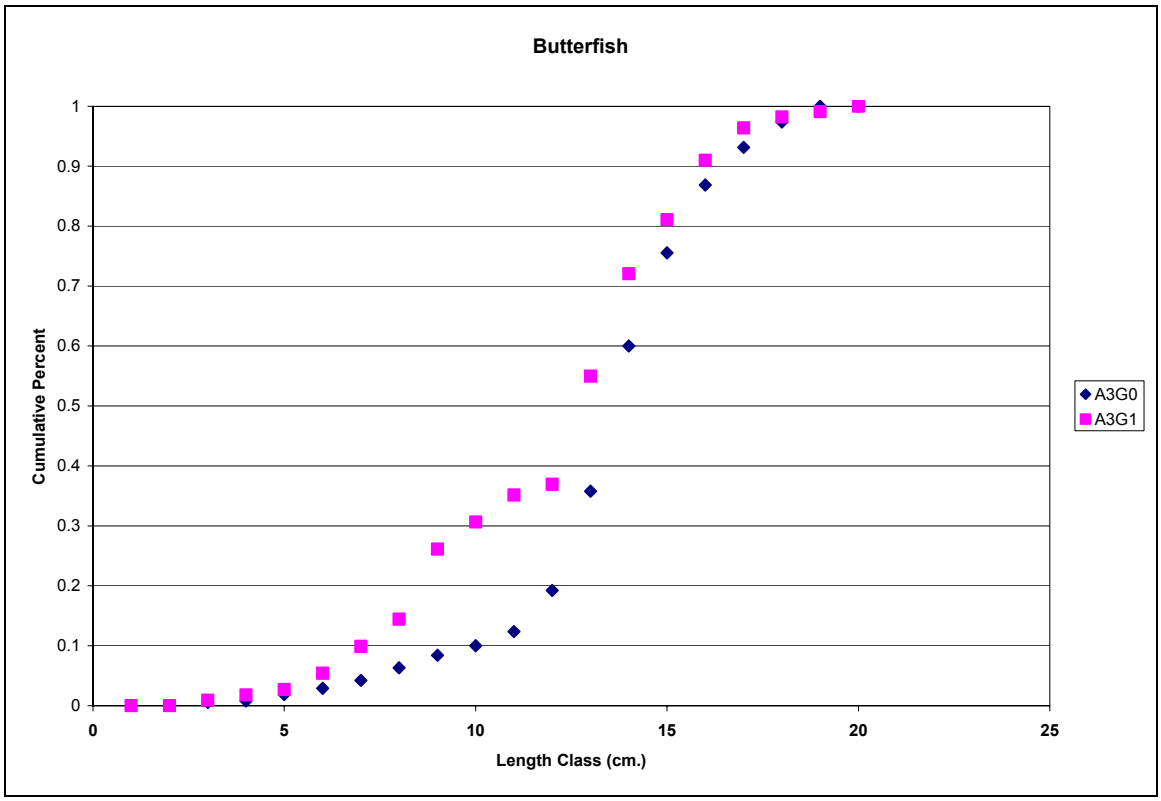

Figure 18 – R/V Albatross IV cumulative catch at length – butterfish.